POLYMORPHISM AND LIFE-HISTORY IN THE *DESMIDIACEÆ.*

By G. I. Playfair.

(Plates xi.-xiv.)

The present paper is to some extent a reply to certain criticisms of my statements in previous papers, regarding the growth of Desmids. Originally made to myself in some correspondence with which I was favoured, these have recently appeared in print in "The Algæ of the Yan Yean Reservoir," by Dr. G. S. West, F.L.S. (Journ. Linn. Soc. Bot., Vol. xxxix., 1909). On page 44, Dr. West remarks:—"Judging by his continual references to 'immature forms,' Mr. Playfair seems to have rather curious ideas on the growth of Desmids. He appears to imagine that a Desmid may change its form, or develop spines or warts, at any time during its existence, losing sight of the fact that, unless dealing with monstrosities, *at least one semicell of any Desmid must be mature.* Cell-division, except under abnormal circumstances, does not take place until the two halves of a Desmid are equally developed, the newer half having arrived at maturity. Consequently, *in any Desmid in which the two semicells are exactly alike, growth has ceased and that individual is mature.* Further alteration of form, excluding the possibility of changes caused by the attacks of parasites, does not take place after the completion of the development of the new half, and spines once formed cannot become bifid or trifid, or in some other way change their nature, as Mr. Playfair appears to imagine." [The italics are Dr. West's].*

* In a footnote Dr. West twits me with having mistaken a diatom for a *Closterium*, quite unconscious apparently that in "Freshwater Algæ of the Third Tanganyika Expedition," (p.140, Pl.5, f.18) he has himself described and figured the same diatom, *Nitzschia reversa*, as *Ankistrodesmus nitzchioides*, sp.n.

With all deference to my distinguished critic, I cannot accept these statements in their entirety, as I believe they are in some respects erroneous. I have, indeed, quoted the remarks at length, because they so clearly and succinctly set forth the opposite of the facts of Desmid-life, as I understand it, and I maintain that the more thoroughly the latter is investigated, the more completely will the truth of this assertion be established. In the first place, in Australia, in warm weather and in shallow, stagnant waters, cell-division *does* take place a second time before the nascent semicells have become fully developed, and it is exactly this that gives rise to the multitude of degenerate forms or "species." I have already given a plain proof of this in my first paper (These Proceedings, p.197, 1907, Plates ii.-v.) from specimens all found in one locality, many years ago. On Pl v., fig.24, is shown a semicell of *Cos. venustum*, and of this species fig. 26(left figure) is a young form(*Cos. trilobulatum* Reinsch, *forma*) developing into a typical *Cos. venustum* through fig.26 (right figure). The middle figure of the three shows a mixed form of *Cos. trilobulatum*, and an immature form (f. *incognita* Playf.); while in fig.25 the latter is shown as a complete cell. In what way could fig.25 have come into existence except by division of the mixed form?—A + B, at division, becomes A + A and B + B.

Again, on Pl.xi., of the present paper, fig 7 shows a chain of eight semicells, which has come about in this way. A,A, formed the original cell, B,B, are the semicells resulting from the first division. Before these semicells are full-grown, or even disconnected, a second division has taken place in both cells (almost always in *both*, showing that it is the outcome of external influences affecting all alike) and C,C, D,D, are produced This specimen was abstracted from a small phial containing living Desmids; before they were disturbed, fully a score of such chains could be observed, with the aid of a Coddington lens, adhering to the glass. On account of their fragile nature, such chains are not often found in gatherings, though halves are not infrequent —three immature semicells, and a more mature fourth; *cf.* Pl.xiv., figs.9-10. In hot weather, and in shallow stagnant waters, however, they are quite the rule of life, and are the origin of the immense number of degenerate forms connected with a species. *Vide* Pl.xiv., fig.11, which is part of one end of a very long chain composed of not less than 24 semicells.

The remaining figures of Pl.xiv., satisfactorily establish this point. In a gathering of Desmids lately obtained, fig.1, *Micr. truncata* var. *decemdentata* was abundant. In the laboratory, the weather being warm, they commenced to divide rapidly. Fig.2 shows the result of the first division, but before the young semicell(b) has completed its growth, a second division has taken place, and fig.3, an entirely distinct type, has been formed. As the result of the fourth division, fig.5 is produced; and, later, I noted complete cells of the type fig.6*a*(practically *Micr. oscitans*). In six rapidly repeated divisions, therefore, we find three distinct degenerate types brought into existence, in addition to the original form. All these immature forms, which were present in quantity, will develop, under favourable conditions, gradually into that represented by fig.1; and this is not itself fully developed, as many specimens were observed with the lateral lobules doubling the teeth(figs.7-8), and thus passing over into the type-form, *Micr. truncata.* In the face of such evidence as this, it is surely quite clear that the word "mature" has no meaning except when applied to the fully-developed and, therefore, final form of the species.

But Dr. West might at least have accepted his own evidence. In "Variation in the *Desmidieæ*"(Journ. Linn. Soc. Bot., Vol.xxxiv., Pl.x., figs.14-15) he has himself illustrated, in the case of *Cos. Regnesii*, what he now denies can take place. He remarks(*l.c.*, p.388), "Many stages were observed in the division of the cells, and it often happened that a second division of the cells commenced before the first was completed. This sometimes continued until several immature cells intervened between the original adult semicells." Compare, also, W. & G. S. West's Monog. Brit. Desm.(Vol. iii., Pl.lxviii., f.25). Again, in "New and Interesting Brit. Frw. Algæ," Journ. R. Micr. Soc., 1896, Part 2, these authors have described(p.159) and figured(Pl.iv., f.56) a similar same state of repeated division in the case of *St. brachiatum.* There is nothing abnormal in this kind of division. Wherever the type is to be found, the same immature form which is produced in this manner may be noted separately, sometimes in quantity, but *then* it is a new species !

Finally, in the last-mentioned paper, it is shown (Pl.iii., f.29, and Pl.iv., f.43) that newly-divided cells may conjugate and produce a zygospore. If such cells can accomplish that rare act, it cannot be believed that they are unable, under natural conditions, to manage mere vegetative division.

In the second place, so far from growth having ceased when cell-division is complete, it is only then that the development of the plant begins, continuing very slowly in the intervals of cell-division. It is because the latter bulks so largely in the life of the Desmid, that degenerate forms of the species are to be found in such abundance and variety, while the fully-developed form itself is so very rarely seen. A true Desmid-species consists of an immense number of distinct polymorphic forms which are partly successive modifications of the sporangial type under stress of rapidly repeated cell-division, partly abnormal (but in no sense monstrous) forms produced by unusual combinations of circumstances, and partly types arising from all these as the result of their struggle to develop upwards towards the perfect examplar of the species.

That spines and processes *do* develop on the cell, has already been conclusively proved in "Some Sydney Desmids." Pl.xii., f.9, shows the well-known *St. orbiculare* with processes full-grown at the basal angles, and developing in pairs down the sides. According to Dr. West, *St. orbiculare* being mature, in the sense that both semicells are alike, cannot develop any further. But we see that it does, and I have myself observed every stage of the development.

Compare also Plate xii. of the present paper, where figs.9-14 exhibit the growth of the upper processes of *St. sexangulare*, and figs.15-18 and 20, form a series illustrative of their very gradual development (granule—spine—process), and of the resulting progression of the cell from one so-called "species" to another. The specimens of the latter series all occurred in profusion in the same gathering(No.60, N.H.S.).

In the following notes, I have made some attempt to exemplify the real conditions of life and development among the *Desmidiaceæ*, the result of fifteen years continued observations of the same "species" from the same localities, at different times and under a variety of circumstances. This kind of study does not, indeed, cause one to become acquainted with a very large number of true Desmid-species, but on the other hand it affords excellent opportunities for gaining an insight into the life, development, and connections of such as are to be found locally. The truth turns out to be exactly what Rev. W. Archer so cautiously suggested in Quart. Journ. Micr. Sci. (New Ser., Vol. ii., 1862). "It is not proved," he says, "that some other form, which in the present state of knowledge we are constrained to suppose a distinct species, may not in truth be only a phase of variation or of development, or an 'alternation of generation' of the actual species, whose extremes of variation, or whose life-history, are as yet unknown."

The *Desmidiaceæ* are essentially plants that require to be studied *on the spot*, by comparison of the contents of repeated gatherings from the same habitat; no reliable determinations can possibly be made from the contents of isolated samples, and this is true also not only of the so-called Unicellular Algæ, but equally of the Diatoms, Peridinieæ, Flagellata, and Infusoria as well. In all these realms of life something like ninety per cent. of the "species" are polymorphic forms of the other ten; and it is only by tracing out their life-histories through the observation of transition-forms, that the specific connection of their innumerable variations can be established.

I am not aware that this aspect of the subject has received much consideration hitherto. Three short papers, however, are mentioned by Prof. O. Nordstedt in the Bibliography of his invaluable Index Desmidiacearum, viz.:—F. B. Carter, "Desmids, their life-history and classification," Amer. Month. Micr. Journ., Vol. x., No.2, Feb., 1889, and Vol. x., No.4, April, 1889. Also, A. M. Edwards, "On 'species' in the Desmidiaceæ," *ibid*, Vol. xv., 1894.* Unfortunately I have not seen these contributions to the subject.

Polymorphism of Doc. trabecula(Ehr.).

There is not the slightest doubt, in my mind, that *Doc. Ehrenbergii, truncatum, crenulatum*(Roy & Bisset), *maximum*(Reinsch), *coronatum, Archerii*(Delp.), *Indicum*(Grun.), *baculoides*(Roy & Bisset), *nodulosum, phæodermum*(Schaar.), *Georgicum*(Lagerh.), *subgeorgicum*(Cushman), *manubrium*(W. & G. S. West), and even *baculum* are all growth-variations of one and the same species, which, by the accident of priority, must be called *Doc. trabecula.* This may appear a large order, but in truth these forms never should have been accorded specific rank in the first instance. A comparative study of these forms soon compels the conclusion that they are all one. According to Turner(Alg. E. India, p.38), Ehrenberg recognised several of them as forms of his *Doc. trabecula*; he cites Infusoria, T.vi., f.ii. Is it possible also to scan the excellent figures in Delponte(T.xix.) without admitting *Doc. nodulosum* as a variation of *Doc. trabecula*? In fig.3, *nodulosum* and *truncatum* are seen as semicells; and fig.10, which, if magnified 416 diameters, is a good illustration of *Doc. trabecula*, would at the lesser magnification be considered a form of fig.2, *i.e.*, of *D. nodulosum.* Compare, too, the figures of *trabecula* (Pl.xxx., figs.12, 13) with those of *maximum*(Pl xxxi., figs.1,2) in W. & G. S. West's Monog. Brit. Desm.(Vol.i.). Fig.1 of *maximum* has even the double basal inflations which seem to be characteristic of European forms of *Ehrenbergii*; so also has the figure of *trabecula* in Pl.xxx., f.11.

* Consult also G. S. West, "Variation in the Desmidieæ," Journ. Linn. Soc., Bot., xxxiv., 1899; W. Schmidle, "Ueber die individuelle Variabilität einer Cosmarienspecies," Hedwigia, 1893, Heft 3; O. Borge, "Ueber die Variabilität der Desmidiaceen," Öfvers. af K. Sv. Vet.-Akad. Förh., 1896, No.4; and J. Lütkemüller, "Beob. über die Chlorophyllkörper einig. Desmid." Oesterr. botan. Zeitschrift, xliii., 1893, No.1.

In this genus all the biological groups and variations of a species are determined by the basal diameter, not by such details as the configuration of the semicell or peculiarities of the apex, which may occur at any stage in the life-history. The clavate *clavatum*(Ralfs), the subclavate(*subclavatum* Wittr.), the cylindrical(*maximum* Reinsch, *baculoides* R. & B.), the excavated *baculum*, *phæodermum*), the undulate, etc., are not, strictly speaking, even variations, let alone species, but merely *shapes* caused by growth, which may, and to a large extent do, occur in every size of the species from lat.10 to lat.54, and probably also, but of this I have no certain knowledge, right up through the highest reaches of lat.60-85.

The character of the membrane is of no value whatever as a proof of identity. If the scrobiculation or granulation arose as the outcome of forces within the cell, they might have some weight as distinctive of variation or subspecies; but as a matter of fact, external circumstances, such as continued stagnation, are very largely, *if not altogether*, responsible for them. In sample No.109,(N.H.S.), gathered from just a few points along the edge of the swamp at Gardener's Road, Botany, upon a single occasion, there are to be found *baculum*, *baculoides*, *Ehr.* f. *minor*, *Ehr.* type, *Ehr.* with 7-undulate base, *Ehr.* f. *elongata*, *trab.* v. *crenulatum*, *trab.* v. *Farquharsonii*(Roy), *all alike plainly punctate-scrobiculate.* Any extent of scrobiculation, therefore, may be met with in cells of any age or size. Compare Pl.xi., f.3*a*, and Pl.xiv., f.11, where the scrobiculæ are replaced by granules in the same cell.

Delponte's *Doc. Ehrenbergii.*—The stout forms of *Doc. Ehrenbergii*—*trab.* v. *Delpontei* mihi, and *trab.* v. *constrictum* mihi, are certainly intermediate between the forms of *Ehrenbergii* proper and *trabecula* v. *crenulatum* (the full-grown form of *trabecula* itself). They exactly bridge the gap, both in size and character, and might indeed be equally well arranged in the *trabecula*-group. However, Delponte(Desm. subalp. p.228, T.xx., figs.1-7) and W. & G. S. West(Alg. Madag., p.45, Pl.v., f.40) have all accepted them as forms of *Ehrenbergii*; I have, therefore, included them within that biological subspecies. As might be expected of forms linking two subspecies, the specimens of var. *Delpontei* vary a good deal in character, specially as regards the apex. The only character that can be unhesitatingly relied upon, is the breadth(basal inflation 30-39μ). W. & G. S. West, in their Monograph, have included this variation with the smaller *Ehrenbergii*-forms. This is quite impossible with Australian specimens. *Doc. Ehrenbergii* proper here, while it has precisely the range of length and breadth given by W. West in Frw. Alg. W. Ire., differs from the British forms in having only one basal inflation at all prominent (*never* as in Monog., Vol.i., Pl.29, figs.10-11), and the apex very often quite smooth. Our forms of Delponte's *Ehrenbergii* either lean towards *trab.* v. *crenulatum* in having a plicate apex, or it has the apical granules strongly accentuated, generally in shape more like the teeth of *Doc. nodosum*, quite unlike any other form in the species.

The case of *Doc. baculum.*—At the outset I had no idea of including *baculum* in the forms of *Doc. trabecula*, in consideration of its axile chloroplast. In gathering No.109, however, it was fairly abundant in excellent condition. There was indeed a single chloroplast, but parietal and curved round the semicell into a tube, no pyrenoids at all being present. It seems certain, therefore, that the chloroplast is first axile, with a central row of pyrenoids; but, as the cell develops, the chloroplast becomes parietal, the pyrenoids are absorbed, and the centre of the cell becomes hollow. Finally, the chloroplast splits up longitudinally into three or four parietal fillets in which the pyrenoids are reformed.

The inflated form of *baculum*, which I figure(Pl.xii., f.2) had a row of decided basal granules; and accompanying it, were cells more like the typical form in Ralfs(Pl.xxxiii., f.5), and W. & G. S. West(Monog., Vol.i., Pl.27, f.1). Of these latter, some had the basal granules replaced by fainter plicæ, others had no basal markings at all, and in other cells again, one semicell would have basal plicæ and the other granules(Pl.xii., f.3). Moreover, a cell was seen(Pl.xii., f.4), *baculoides* in shape, but the breadth of

Ehrenbergii f. *minor*, one semicell showing distinctly the basal plicæ. The plicæ, still more faint, were also noted in a cell of var. *Ehrenbergii*(Pl.xii., f.5). These plicæ are not visible at the edge, over the margin of the cell; and it has been contended that they are of an entirely different nature from the basal granules. On the other hand, I find them occupying the same position on either side of the suture, and replacing the granules in the same cell. Neither granules nor plicæ are permanent; as the cell develops they are drawn out flat and disappear. Not only so, but the *baculum*-shape may be observed on a larger scale(Pl.xii., f.1*b*), with the *baculum*-chloroplast, but without either granules or plicæ. Finally, a cell has been observed(Pl.xii., f.1*a*) having parietal tæniæ proceeding out of an axile chloroplast. *Doc. baculum*, therefore, can be looked upon only as a young growing form of var. *Ehrenbergii*, and a variation of *Doc. trabecula*. The genus *Pleurotænium* also must be included in *Docidium*.

Notes on, and descriptions of various forms.

DOCIDIUM TRABECULA Ehr.

Doc. trabecula Ehr., *cf.* Näg., Gatt. einz. Alg. T.vi., f.*Ab*.

Long. semi. 186; lat. bas. 40, centr. 36, ap. 18μ(Pl.xi., f.1*b*): long. cell. 380; lat. bas. 44, centr. 37, ap. 21μ; Näg. *l.c.*

Auburn.

This is Nägeli's form, the dimensions being in perfect agreement. It is a younger form than that generally figured as *Doc. trabecula*(Pl.xi., f.9). A still more immature condition(*D. truncatum*) is shown joined to it(f.1*a* and Pl.xii., f.7). Such forms are quite common here.

DOC. TRABECULA Ehr., another form(Pl.xi., f.9).

Long. 300-335; lat bas. 35-38; centr.30-33; ap. 20-21μ.

Guildford(78, 114).

In quantity(114), with var. *Delpontei* mihi, the intermediate form. This gathering afforded another proof that incrassation, scrobiculation, and granulation of the cell-membrane are due to stagnation. It remained for a month corked up in a small phial standing in a weak light. On examination, the living cells were found to be yellow, incrassate, strongly scrobiculate, and in some cases even granulate; whilst the cells originally dead, of which there were a considerable number, remained unaltered, with a faintly scrobiculate hyaline membrane. This breadth of *trabecula* corresponds to *truncatum* f. *gracilior* Richter.

Doc. TRABECULA Ehr., forma. (Pl.xi., f.4).

Forma parte inferiori semicellularum cylindracea; lateribus parallelis, sursum ad apices rapide convergentibus; apicibus rugis circ.12(visis 7) ornatis. Long.346; lat. bas.44; centr.40; ap.21μ.

Guildford(78).

This is the outgrowth of var. *Farquharsonii*(Roy).

Var. FARQUHARSONII(Roy). (Pl.xi., f.5).

Long.290; lat. bas.55; centr.51; ap.24μ.

Botany(109).

Cf. W. & G. S. West, Monog. Brit. Desm. Pl.xxix., f.6.

Var. BREFELDII(Istvánffi), f. GRACILIOR. (Pl.xiii., f.23*a*).

Forma gracilior; apicibus late-rotundatis. Long. semi.67; lat. bas.30; max.38; ap.20μ.

Auburn. Cum var. *truncato*.

Cf. Istvánffi, Felso-magyar. tozeg. megvizs. T.ii., f.35.

Develops into var. *truncatum*. Compare Pl.xi., f.3, the two inner semicells.

Var. TRUNCATUM(Bréb.). (Pl.xi., f.1*a*, 2, 3*a*).

Long.170-228; lat. max.37-45; ap.18-20μ.

Auburn(57, 67, 70, 85, 104, etc.).

When the heat causes the large forms of *Doc. trabecula* to divide repeatedly, they descend greatly in size and shape(*cf.* Pl. xi., f.7). These degraded forms, however, gradually pull themselves together, and var. *truncatum* is the result. It is the lowest form of *Doc. trabecula*, with the exception of var. *Brefeldii*(Istvánffi), Pl.xiii., f.23*a*, and allied shapes like var. *crassum* Boldt(Sibir.

Chlor. T.vi., f.44). Var. *truncatum* is the form with which the cell makes a new start in longitudinal growth.

Var. CRENULATUM(Roy & Bissett), non Ehr. (Pl.xi., f.13).

Forma *Doc. trabeculæ* semicellulis apices versus attenuatis, rugis 14-16(visis 8-9) intra marginem apicalem instructis. Long.520-800; lat. bas.35-54; centr.32-51; ap.20-32μ.

Ubique. (See slides 1, 7, 10, 21 for fine specimens).

Cf. Roy & Bissett, Jap. Desm., f.19. I have never, however, seen a specimen with a granulate apex. Here the apex is invariably plicate within the margin. The younger cells are attenuated from about the centre, but in more mature specimens only near the tip. This attenuate tip, with its plicæ, is characteristic of this form, which is the variation of *trabecula* commonly found in this country. Lat. bas.42-45 is a general size for well-grown specimens. Roy & Bissett, *l.c.*, identify this form with *Doc. crenulatum* Ehr., but this seems doubtful, as Bailey (in Ralfs, p.219) identifies the latter with *nodulosum*. *Doc. crenulatum* Ehr., was an American form, and the figures in West(Frw. Alg. W. Ire., Pl.19, f.8-12) show that the apex of *nodulosum* (*coronatum*) may easily appear crenulate, or the undulations in the sides might have given rise to the name; whereas in Roy & Bissett's form the plications do not catch the eye even under a high magnification.

Var. MAXIMUM(Reinsch), forma. (Pl.xi., f.15-16).

Forma semicellulis apices versus paullo attenuatis; apicibus truncatis, rugis 14-16(visis 8-9) instructis. Long.730-875; lat bas.44-58; centr.38-45; ap.28-30μ.

Collector, Auburn(7, 10). Cum priori rarius.

Doc. maximum Reinsch, is only the well-grown and strictly cylindrical form of *trabecula*, with a pronounced basal inflation. Compare W. & G. S. West, Monog., Pl.xxx., f.12, 13, with Pl.xxxi., f.1, 2. It is surely impossible to deny that these are the same plant in different stages of growth. In this country, any specimen of *trabecula* over 400μ long is certain to have a plicate apex;

hence our forms of *Doc. maximum* differ in this respect from European cells. This variation is rare here, and the two cells figured are the nearest approach to the shape of *maximum* that I have ever seen.

The order of growth in the *trabecula*-stage of this species is, (1) var. *Brefeldii*, (2) var. *truncatum*, (3) *trabecula*, (4) var. *crenulatum*, (5) var. *maximum*—the last occasionally only.

Var. DIADEMATUM, n.var. (Pl.xi., f.8).

Forma lateribus parallelis apices versus convergentibus; basi levissime inflata; apicibus granulis validis distinctis ornatis. Long.494-600; lat. bas.37-43; ap.21-24μ.

Collector; Coogee(1); Prospect(43); Auburn(10).

Found with var. *Ehrenbergii* and var. *crenulatum*. This form distinctly shows transition going on from the slenderer forms of var. *Ehrenbergii* and var. *Delpontei* to the stouter ones of *trabecula* proper, by increase in breadth from the base upwards. The upper part of these semicells belongs to the former, as the apex clearly shows; the lower half to the latter.

This coroneted apex is never found in the *trabecula*-forms proper, but is peculiar to the stout form of *Ehrenbergii*(var. *Delpontei* mihi). The apex, though it looks so strong, is not permanent; the granules are merely rucks in the membrane, and, as the inflation of the semicell proceeds upwards, it smooths them out, producing the typical *crenulatum*-apex with faint plicæ.

Subspecies *Doc. Ehrenbergii* mihi.

I use this expression simply as a subheading to indicate a definite biological group of forms within the species. The word subspecies has formerly been embodied in the name of the Desmid. This is, however, not absolutely necessary, and complicates the nomenclature to such an extent as to be quite intolerable. It is absurd that one should have to employ a whole line of print in order to make passing reference to some particular form; and, while it is most important that the various forms should be arranged according to their natural biological connection, yet why should it be thought necessary to embody a system of classification in the name of any organism? I have, therefore, made every distinct form a variation of the type holding priority.

Subspecies *Ehrenbergii* is only the forma *minor* or, as only breadth counts in these long forms, the forma *gracilior* of *trabecula* proper. Disregarding what may be termed infantile forms, the breadth in this group ranges from 18μ to 37μ, while in *trabecula* proper the range is from 37μ to 76μ.

Doc. TRABECULA var. EHRENBEGII(Bréb.).

Long.264-608; lat. bas.18-28; centr.17-25; ap.12-18μ,

Ubique.

The sizes include f. *minor* and var. *elongatum.* (See note, *supra*, on Delponte's *Ehrenbergii*).

Var. CONSTRICTUM, n.var. (Pl.xi., f.11).

Forma var. *Ehrenbergii* proxima, cylindracea, apices versus levissime attenuata; lateribus parallelis; apicibus subtruncatis; supra inflatione basali valde constricta et sursum leviter excavata et inflata (ad *baculum* acc.), lateribus in excavatione undulatis. Membrana vulgo dilute scrobiculata. Long. 544-606; lat. bas.26-28; centr.24-25; ap.18μ.

Prospect(43), Coogee(1).

The only differences between this form and var. *Ehrenbergii* are the decided constriction, and curious excavated appearance above the basal inflation, in which lie one or two lesser undulations. The shape is somewhat like *Doc. baculum*(compare Pl.xi., f.14). This form is intermediate between var. *Ehrenbergii* and var. *Delpontei*; the excavated appearance is, I consider, caused by the swelling of the cell above the basal undulations preparatory to a widening of the isthmus. The base is somewhat like that of *Pl. Georgicum* Lagerh., Amerikas, f.29, but the semicell hardly at all inflated.

Var. DELPONTEI mihi. *Pl. Ehrenbergii* Delp., T.xx., f.1-7.

Forma inter var. *Ehrenbergii* et *trabeculam* var. *crenulatum* intermedia. Semicellulæ cylindraceæ, basi levissime inflatæ et sursum interdum inflationibus minoribus, ad apices versus leviter attenuatæ; apicibus truncatis, rugis 14-16 (visis 8-9), vel sæpe granulis 12-16 (visis 7-9), vel granulis 6 (visis 4) infra marginem ornatis. Sutura prosiliente. Membrana vulgo dilute scrobiculata. Long.390-500; lat. bas.30-39; centr.28-35; ap.20-27μ.

Auburn(7, 10, 16, 21), Coogee(1, 4), Guildford(78, 114).

Wherever well-grown specimens of *Doc. trabecula* var. *crenulatum* are met with, the above form is sure to be found accompanying them, along with some form of var. *Ehrenbergii.* In slide 1A(N.H.S.) mounted haphazard from a pure gelatinous crust of Desmids obtained at Coogee, there may be seen, side by side, four forms exhibiting plainly the development from var. *Ehrenbergii* to var. *crenulatum.* (1) Var. *Ehrenbergii*, lat. bas. 20μ(Pl.xi., f.10). (2) Var. *constrictum* mihi, lat. bas.28μ(Pl.xi., f.11). (3) Var. *Delpontei* mihi, lat. bas.34μ(Pl.xi., f.12). (4) Var. *crenulatum*, lat. bas.42μ(Pl.xi., f.13). The forms of var. *Delpontei* seem to have a strongly granulate apex more commonly than any other form in this species. Pl.xi., f.17-21 show five varieties of apex found in specimens of this variety.(*Vide* note on this variation, *supra*).

Forma MEDIOLÆVIS (Playf.). *Pl. mediolæve, ante*, 1907, Pl.ii., f.10.

Long.410-684; lat. bas.30-38μ.

Auburn.

This is merely an incrassate form of var. *Delpontei* with strongly accentuated scrobiculæ. The cells have grown to their full length, as the square apex shows; and a slight further growth has taken place at the suture. The apex in this form is exactly as figured by Delponte, T. xx., f.7. My forma *gracilior*, l.c., p.162, is only *Ehr.* f. *minor* in the same condition.

Forma CONSTRICTA, n.f. (Pl.xi., f.14).

Forma latitudine ut in var. *Delpontei*; semicellulis ut in var. *constricto* conformatis; apicibus rugis granulisve ornatis. Long. 518-750; lat.bas.30-39; constr.24-31; centr.26-34; ap.16-27μ.

Auburn(7, 10, 21), Botany(108, 109).

Var. OVATUM, n.var. (Pl.xi., f.6).

Forma *Doc. ovato* Nord. consimilis; semicellulis e sutura valde inflatis; lateribus ad apices rapide convergentibus; apicibus truncatis. Forma var. *Delpontei* e divisione producta. Long. semi. 95; lat. max.44; ap.21μ.

Coogee(slide 1A).

Var. INDICUM(Grun.), *non* Turner, Frw. Alg. E. Ind., T.iv., f.8.

Long.624-790; lat. bas.28-36; centr 24-33; ap.22-24μ.

Sydney water-supply(80, 81).

A plankton form of var. *Ehrenbergii*, or one caused by semi-plankton-conditions (a strong current of water). I have never met with it except in the Sydney water-supply.

Var. BACULOIDES(Roy & Bisset), forma.

Forma brevior, inflatione basali unica tantum. Endochroma in tænias parietales 3-4 ordinata. Long.200-276; lat. bas.15-18; centr.14-15; ap.10-12μ.

Botany(109A). Cum formis sequentibus duabus.

The semicells were the shape of Pl.xii., f.3*a*, but without the basal plicæ.

Var. BACULUM(Bréb.) (*Doc. baculum*). (Pl.xii., f.2, 3).

Long.178-254; lat.bas.12-15; constr 9-10; centr.13-15; ap.8-10μ.

Botany(109A). Cum priori.

Endochroma in lamina unica sed parietali disposita. Pyrenoidibus nullis. In an empty semicell, the base of which was tilted, the basal granules were plainly to be seen. They were 16 in number, each with a plication ascending half-way up the basal inflation. It is noteworthy that there is the same number of plicæ in *Doc. manubrium*, Frw. Alg. Madag., p.44.

Forma MAJOR, n.f. (Pl.xii., f.1*b*).

Forma granulis basalibus nullis vel inconspicuis; semicellulis perfecte cylindraceis, supra isthmum valde inflatis et sursum interdum levissime constrictis; apicibus aut rectis truncatisque aut rotundatis levissime inflatis, granulis plicisve minutissimis ornatis. Endochroma in lamina unica ut videtur convoluta, ad apicem planam ordinata.

A. Long. semi.200; lat. bas.21; constrict.12; centr.14; ap.16μ.

B. Long. semi.244; lat. bas.26; constrict.16; centr.17; ap.16μ.

Auburn, Guildford.

A. joined with var. *Ehrenbergii*, B. with var. *Delpontei*, the endochrome of the latter specimen not noted. The semicell is the shape of var. *baculum*, but the basal granules or plicæ are wanting, and the size is larger. The interest and importance of the find lies in the fact that, whereas the endochrome of the var. *Ehrenbergii* semicell was normal, the part within the basal inflations of both semicells was evidently in the form of a parietal tubular lamina. This portion exhibited the appearance of vertical fibrils, and this slightly supports my contention that the parietal lamina of var. *baculum* divides vertically into four fillets as the cell develops into var. *Ehrenbergii*.

Var. EHRENBERGII(Bréb,), forma. (Pl.xii., f.5).

Forma ad suturam utrinque serie plicarum obscurarum(circ. 9-10 visis) ornata. Long.516; lat. bas.25; constr.21; centr.23; ap. 17μ.

Botany(109A). Cum antecedenti.

All the forms in 109 had distinctly punctate-scrobiculate membranes. The three foregoing all had the same smoothly rounded but truncate apex (Pl.xii., f.8), and showed such an unmistakable similarity that there could be no doubt whatever of their specific identity. *Doc. manubrium* W. & G. S. West, Frw. Alg. Ceylon, Pl.19, f.11, and Frw. Alg. Madag., Pl.5, f.31, is simply var. *Ehrenbergii* and var. *Delpontei* in which the basal plicæ of var. *baculum* have persisted. It should stand as *Doc. trabecula* var. *manubrium*. The form here noted is practically the same, but the plicæ very faint. What difference is there between Pl.xii., f.1*a*, and Frw. Alg. Ceylon, Pl.19, f.11?

Var. PYGMÆUM, n.var. (Pl.xii., f.6).

Forma inflatione nulla vera, sed paullo supra basin constrictione levi; apices versus leviter attenuata; apicibus truncatis glabris; sutura prosiliente. Endochroma in tænias disposita. Long.206; lat. bas.12; centr.12; ap.9μ.

Botany(108).

COSMARIUM RECTANGULARE Grun.

A large number of well-known "species" combine to form the life-history of *Cos. rectangulare.* All of them are mere growing forms, developing one into another under suitable conditions. There is not the slightest doubt about these identifications, as all the forms occur together, and show that peculiar likeness, under the microscope, which it is impossible to describe or put on paper. Wherever one is found, the others are sure to appear on diligent search. The species is very local round Sydney; after large and repeated gatherings, not a single one of any of the forms here mentioned has been obtained from such rich localities as Coogee, Botany, and Centennial Park. The species is entirely confined to the clay-soil district of Auburn, Guildford, Fairfield, Canley Vale, etc., where it occurs in profusion; and although there are other and permanent waters in the vicinity, yet its variations are not found except in the tiny drainage-pools and swampy patches of ground along the Southern railway line, and at Auburn. Nor have any of them been noted in the Sydney water-supply, the drainage of a large area at some distance from Sydney. As confirmatory of my conclusions about these forms, it should be remarked that many years ago at Collector, 250 miles from Sydney and 2300 feet above sea-level, I found all the principal variations associated together before.

The "species" included in this life-history are *Cos. pseudoprotuberans* Wille(not Kirchner), and *β angustius* Nord., *Cos. sulcatum* Nord., *Cos. repandum* Nord., *Cos. sexangulare* Lund., *Cos. hexagonum* Elfv., *Cos. Elfvingii* Rac., and var. *saxonicum* Rac., *Cos. cyclopeum* Playf., *Cos. odontopleurum* Arch.(Roy & Bissett, Scottish Desm., Pl.ii., f.13), (?)*Cos. flavum* Roy & Bisset, *l.c.* Pl.ii., f.17, and *Cos. protuberans* Lund. The last three I have not seen, but the others are certain. *Cos. flavum* must go wherever *Cos. odontopleurum* goes—the zygospores are exactly alike. The latter has already been placed as a f. *minor* of *Cos. repandum* (*vide* W. & G. S. West, Monog. Br. Desm., iii., 54).

The following variations of this species have been observed here :—

Cos. RECTANGULARE var. NODULATUM Playf., *ante*, 1908, Pl.xii.,f.5

Long.50-62; lat.38-44; crass.30-36; ap.17; isth.10μ.

Auburn, Guildford(23, 45, 60). Cum forma typica.

This is, as far as I know, the final and fully-developed form. A vagueness about the apex, which seems to belie this, is probably due to the *appearance* of incrassation at the basal angle and upwards, making the upper part of the cell look weaker by contrast.

Forma MINOR. (Pl.xiii., f.5).

Long.36-38; lat.28-30; ap.14, isth.10μ,

Guildford(60).

Both with and without nodules. This form is almost var. *Cambrense* (Turn.) W. & G. S. West, but a little broader. The latter in same gathering.

Var. CAMBRENSE(Turn.) W. & G. S. West, forma.

Forma semicellulis paullo latioribus; *infra margines apicales* juxta angulos superiores nodulis singulis utrinque praeditis; lateribus angulisque plus minusve rotundatis. Long.36; lat.28; ap.14; isth.10μ.

Guildford(60).

The nodules in this form were below the apical margin.

Var. DENTATUM, n.var. (Pl.xiii., f.4*b*).

Forma semicellulis ad var. *nodulatum* accedentibus; lateribus e basi fere parallelis; angulis basalibus dentatis. Long.50-52; lat.38; ap.20-21; isth.8-12μ.

Guildford(89, 114).

Var. ALTIUS, n.var. (Pl.xiii., f.4*a*).

Forma semicellulis basin versus quadratis; angulis basalibus rectis; lateribus e basi parallelis sursum ad apices convergentibus; apicibus late-truncatis; angulis lateribus et superioribus levigatis. Long.60; lat.40; ap.20; isth.8μ.

Guildford(89). Cum priori.

Var. QUADRIGEMINATUM Playf., *l.c.*, p.614. (Pl.xiii., f.1).

Long.45-52; lat.34-38; crass.25; ap. fronte 15-20; latere 14μ.

Guildford(60), Fairfield(79). Cum priori rarius.

With its four nodules at the apex, this has the appearance of being a collateral type. It is, I think, certain, however, that it resolves itself into var. *nodulatum*. The form of var. *Cambrense*, supra, is practically a forma minor of this, as it must have four nodules.

Var. NOTATUM, n.var. (Pl.xiii., f.2).

Semicellulæ altiores, magis quadratæ; lateribus parallelis; apicibus leviter arcuatis: angulis inferioribus ut in *Cos. repando* Nord. notatis. Long.50-51; lat.40-42; crass.24-31μ.

Collector.

This has the same markings under the basal angles as *Cos. repandum* ; they foreshadow the accentuated angles and pointed end-view of var. *nodulatum*.

Var. REPANDUM(Nord.). (Pl.xiii., f.12).

Forma lateribus perfecte rectis. Long.43-50; lat.30-40; crass. 22μ.

Collector.

Cf. Nord., Frw. Alg. N. Z., p.58, Pl.6, f.14. This form probably develops into var. *nodulatum*; while Nordstedt's form, with hollow sides, grows into var. *dentatum* mihi.

Var. ANGUSTIUS(Nord.), *l.c.*, p.58, T.vi., f.15, 16.

Long.32-33; lat.24; isth.8μ.

Collector.

According to outline, this really goes under var. *repandum*, of which it is the forma *minor*. Its sides are not so sloping as in var. *Finmarkiæ*. Var. *angustius* has the same relation to var. *repandum* that var. *cyclopeum* has to var. *Finmarkiæ*, or var. *Cambrense* to var. *notatum*.

Cos. RECTANGULARE Grun., type.

Long.43; lat.33μ.

Guildford(60), Auburn(85).

Var. *minus*(Wille), (*Cos. gotlandicum β minus* Wille, Norges Fersk., p. 31, T.i., f.13) I have not yet noted, but I think it certainly a var. of *rectangulare*. From the figures given by Wille and Wittrock, and lately by W. & G. S. West in their Monograph, it appears that the common form in Europe is depressed in the semicell, while ours are more generally subquadrate.

Var. FINMARKIÆ, n.var. (Pl.xiii., f.13).

Forma lateribus e basi plana rapide divergentibus; angulis superioribus plus minusve rotundatis; apicibus arcuatis. A vertice semicellulæ ellipticæ utrinque inflatæ. Long.38-42; lat.33-38; crass.22-27μ.

Collector, Canley Vale(110).

Develops into var. *repandum* or var. *nodulatum* by broadening of the base, the sides becoming less divergent. I had this originally down as var. *pseudoprotuberans* (Kirchner), but the forms given by Nordstedt, Desm. Grönl., T.7, f.3, and W. & G. S. West, Monog. iii., Pl.lxxii., f.6-8, certainly belong to *Cos. contractum* Kirch., as does also the *Cos. sulcatum* var. *incrassatum* W. & G. S. West, Alg. Ceyl., Pl.20, f.36-38, a form extremely common in this district. The variations of *Cos. rectangulare* (including *sulcatum*, etc.) never have an incrassate centre or an open sinus. *Cos. contractum*, *Cos. ellipsoideum*, *Cos. foveatum* Schm.(= *Cos. incrassatum* Playf., according to G. S. West), and *Cos. pseudoprotuberans* Kirch., are young forms of *Ar. Bulnheimii* Rac.,(Desm. Nowe, T.vi., f.17) of which *Xan. inchoatum* Nord., and *β mammillatum* Playf., are variations. These forms are all commonly incrassate in the centre of the semicell; and never have a linear sinus, but always an open one, or, at most, one with parallel sides. Compare the *Cos. contractum* in Rac., Desm. Polon., T.x., f.10. The development of the latter also is from the top downwards; the broad truncate apex tends to remain and become broader. In Wille's *pseudoprotuberans*,(= var. *cyclopeum* Playf., forma) which is certainly a variation of *Cos. rectangulare*, the semicell develops from the base upwards, the truncate apex being continually obliterated. Wille's form is said(Monog., iii., p.70) to be a variation of *Cos. protuberans* Lund., and this I think very probable. The latter, then, must be considered a variation of *Cos. rectangulare*, a form indeed smaller than any I have yet observed, but Gutwinski has recorded the type as low down as 28 x 25. Like *Cos. protuberans* Lund., all these *rectangulare*-variations have a minutely and closely punctato-scrobiculate membrane, not always so evident as in my figures, but always visible. Relying, therefore, on the evidence of Nordstedt and W. & G. S. West, I have relegated the name *pseudo-protuberans* to *Cos. contractum*. But my form in Pl.xiii., f.13, is manifestly(38-42 x 33-38) the f. major of Wille's specimen(33 x 27) and is certainly identical with the "*forma angulis superioribus semicellularum rotundatis*" of Borge, Norska Finmark, p.12, f.10, upper semicell. I have, therefore, given it the name var. *Finmarkiæ*.

Var. ROTUNDATUM, n.var. (Pl.xiii., f.17).

Forma var. *Finmarkiæ* angulis superioribus valde rotundatis. Semicellulæ subreniformes; lateribus e basi plana divergentibus, minimo spatio rectis; angulis lateralibus late-rotundatis; dorso latissime et perfecte arcuato. Membrana punctato-scrobiculata. Long.38-42; lat.32-36; crass.21; isth.8μ.

Guildford(114), Canley Vale(110).

This form, of whose connection there is no doubt, affords an excellent example of the smoothing down of a characteristic feature in the stress of cell-division. In the smaller forms compare var. *reniforme* and var. *subreniforme*.

Var. HEXAGONUM(Elfv.) W. & G. S. West, forma MAJOR. (Pl.xiii., f.3).

Forma major, præ latitudine paullo longior. Semicellulæ magis quadratæ, lateribus longioribus; a vertice ellipticæ mediis lateribus angulatis, polis late-rotundatis. Long. 44; lat. 36; crass. 24μ.

Guildford.

Compare Elfving, Desm. Finsk. T.i., f.8; synonym *Cos. Elfvingii* Rac., Desm. Polon., p.27.

Var. SAXONICUM(Rac.). (Pl.xiii., f.6).

Long. 44; lat. 40; isth. 8μ.

Canley Vale(110).

Syn. *Cos. Elfvingii* var. *saxonicum* Rac., Desm. Nowe, T.i., f.14.

This is practically var. *Finmarkiæ* with the basal angles developed into a tooth. Many other forms occasionally show the tooth, sometimes only on one basal angle. The tooth is not permanent, but develops, as the cell grows, into the basal angle of var. *nodulatum*.

Var. AUSTRALE, n.var. (Pl.xiii., f.15).

Forma var. *saxonico*(Rac.) consimilis(sine dentibus); lateribus brevibus, leviter divergentibus; angulis basalibus acuminatis, superioribus fere rectis plus minusve rotundatis; apicibus arcuatis. Membrana minute punctato-scrobiculata, interdum plicis subapicalibus binis, ternisve ornata. A vertice semicellulæ ellipticæ polis rotundatis (vel acuminatis ?) utrinque inflatione glabra, bi-, tri-cuspidata vel bi-papillata instructæ. Long. 38-42; lat. 36-38; crass. 22-25μ.

Collector, Guildford(69).

The above bears considerable resemblance to *Cos. sulcatum* Nord.,(forma) W. & G. S. West, Alg. Madag., Pl.9, f.28; and I had, at first, the intention of making that the type-form under the name of var. *Madagascarense*, However, the Madagascar form is slightly flattened above, has more pointed angles, more sloping sides below and the typical *sulcatum* end-view, in all of which it leans to var. *sulcatum*, and is indeed the transition-form between the latter and var. *australe*.

Forma. (Pl.xiii., f.14).

Forma apicibus plus minusve acuminatis, ceteris ut supra. Long.42; lat.38; crass.24μ.

Guildford(69). Cum priori.

This form shows the beginning of growth towards a truncate apex and subhexagonal outline.

Var. OCELLATUM, n.var. (Pl.xiii., f.16).

Forma incrassatione ad angulos laterales instructa. Pyrenoidibus singulis magnis. Long.40-42; lat.34-35; crass.20; isth.6μ.

Guildford(89).

The peculiar appearance across the lateral angles is not a true ocellus, but apparently an incrassation. It seems to be one of the ways by which the angle is obliterated.

Var. PATEREFORME, n.var. (Pl.xiii., f.18).

Forma semicellulis subreniformibus; basi plana; angulis lateralibus late rotundatis; lateribus levissime arcuatis ad apices convergentibus; apicibus truncatis; angulis superioribus pæne levigatis. Long.40-42; lat.35-37; ap.12; isth.8μ.

Guildford(89), Canley Vale(110).

Forma. (Pl.xiii., f.19).

Forma angulis lateralibus macula incrassata ornatis; ceteris ut supra. Long.40-44; lat.35-38; basis 30-32; ap.14; isth.8-10μ.

Canley Vale(110), Guildford(114).

Var. SEXANGULARE(Lund.). (Pl.xiii., f.22).

Forma senilis, membrana incrassata. Long.40; lat.37; isth.8μ. Collector.

Cos. sexangulare Lund., Desm. Suec. T.ii., f.23. The hexagonal form is not stable, but gradually develops into a higher form. Occasionally, however, it becomes fixed by incrassation.

Var. SULCATUM(Nord.). (Pl.xiii., f.21).

Long.37; lat.32; crass.18μ.

Collector, Moura.

Cos. sulcatum Nord., Alg. Sandvich. T.i., f.18, 19. This is sciagraphically a variation of *sexangulare* (as is also *papillatum* mihi) with more pointed lateral angles and narrower base. Exactly the same two forms occur here in *Cos. biretum.* The dimensions given by Lundell agree perfectly with Nordstedt's highest for *Cos. sulcatum.* The sulcæ are not characteristic of this variation, or indeed of any of them, being sometimes present and sometimes not, in all forms of var. *Finmarkiæ* and var. *cyclopeum* besides. In none have they any permanence, being simply a transitory device to allow for the considerable development in thickness (*crass.*) characteristic of the highest forms. In the lower forms they are often reduced to a single granule, or refractive (but not incrassate) spot, generally just below the apical margin but sometimes nearer the centre of the semicell. These hexagonal forms do not constitute a separate life-history within the species, or a distinct side-issue of it. In different sizes they alternate in development with those forms having a regularly arcuate apex. Like most other Desmids, so far from being fixed unchangeable organisms, they are merely *shapes, types of outlines* which occur over and over again with varying dimensions in different stages of the life-history of the plant. The species at its simplest is not a form, but a series of forms, through which development moves. This series, however, is, in *Cosmarium,* obscured largely by a number of degenerate forms produced by repeated division, and by a third set of forms the product of environment. In this species, however, I have noted a well-marked series in major and minor sizes. Compare *reniforme-subreniforme-cyclopeum-subhexagonum,* with *rotundatum-patereforme-australe-nodulatum.* There may be in a species, a forma *minima,* forma *minor,* forma *major,* and forma *maxima* of the same shape, but never under any circumstances does any one of these develop directly into another—always through at least one different form.

Var. PAPILLATUM, n.var. (Pl.xiii., f.20).

Forma var. *sulcato* consimilis, sulcis nullis, papilla autem subapicali ornata. Long.35; lat.33; basis 22; ap.12; isth.8μ.

Canley Vale(110).

In all the(110) specimens the papilla was general and distinct, showing plainly in side-view, whether it occurred in var.*cyclopeum*, var. *subhexagonum*, var. *subreniforme*, or var. *papillatum*. This is another point that goes to show that differences in the membrane are largely due to conditions of environment affecting all alike. In other localities, the papilla is rare or only faintly expressed, the form of the cell being the same.

Var. SUBHEXAGONUM, n.var. (Pl.xiii., f.8*a*, 11).

Forma semicellulis var. *cyclopeo* congruentibus, subhexagonis autem; dorso elevato, plus minusve angulato; interdum papillis subapicalibus 1-3 instructis. Long.33; lat.29; ap.10; isth.6μ.

Guildford(114).

Found also as :—

Forma mixta 1.—var. *subhexagonum* et var. *cyclopeum*. Long. 33; lat. var. *subhex*.29, var. *cycl*.27; isth.6μ.

Forma mixta 2.—var. *subhexagonum* et var. *subreniforme*. Long.34; lat. var. *subhex*.30, var. *subren*.25; isth,5μ.

Guildford(114).

Var. CYCLOPEUM(Playf.), *ante*, 1907, Pl.v., f.12.

Granulum parvum infra apices saepissime abest. Pyrenoidibus singulis. Endochroma verticaliter divisa. Long.30-36, lat.26-32; basis 18; crass.18; isth.6-8μ.

Collector, Guildford(114). (Pl.xiii., f.7).

This form, first found years ago at Collector, is not uncommon here along with other forms of the species. It turns out to be the same as Wille's *pseudoprotuberans* f. *minor* in Norges Fersk., Pl.i., f.18. The breadth being worked out from the figure, his dimensions are 33 × 27 × 21, isth.8μ. It has no connection with *Cos. pseudoprotuberans* Kirchner.

Var. SUBRENIFORME, n.var. (Pl.xiii., f.9).

Forma e var. *cyclopeo*, angulis lateralibus basalibusque confluentibus producta. Semicellulæ subtriangulares; apicibus angustis subtruncatis; angulis basalibus latissime rotundatis; lateribus sursum leniter deplanatis, ad apices rapide convergentibus; apicibus infra marginem interdum papilla instructis. A vertice ellipticæ, utrinque leviter inflatæ, polis obtusis. Pyrenoidibus singulis. Endochroma verticaliter divisa. Long.30-35; lat.23-30; crass.15; ap.8-12; isth.5-6μ.

Canley Vale(110), Guildford(114).

The basal angles of this form are always broadly rounded, never sharp as in *Cos. nitidulum* De Notar., and *Cos. galeritum* Nord. Var. *subreniforme* and var. *reniforme* are produced from var. *cyclopeum* by repeated division.

Forma mixta—var. *cyclopeum* et var. *subreniforme*. Long.30; lat. var. *cycl* 28, var. *subren.*25; isth.6μ.

Guildford(114).

Var. RENIFORME, n.var. (Pl.xiii., f.10*a*).

Forma e. *subreniformi* producta, dorso depresso. Semicellulæ depressæ, pæne reniformes; dorso leniter arcuato. Membrana minute punctato-scrobiculata.

Found as yet only as mixed forms :—

Forma mixta 1.—var. *reniforme* et var. *subreniforme*. Long. 33; lat. *renif.* 29, *subrenif.* 29, ap.10; isth.6μ.

Fairfield(116).

Forma mixta 2.—var. *reniforme* et var. *cyclopeum*, f. Long. 27; lat. *renif.* 25, *cycl.* 23; isth.5μ.

Guildford(114).

The latter is practically identical with the mixed form figured by Borge, Alg. v. Schweden, T.2, f.26; the size also is the same. It has already been connected with *Cos. rectangulare* by W. & G. S. West, Monog., p.56.

I had at first intended arranging all these variations in three sections or subspecies, viz.:—(1) lower sides parallel, (2) lower sides divergent, (3) semicells hexagonal. Simple and reasonable as this classification looks, when only a few forms are known, it is entirely artificial and broke down at once as soon as proper research was made into the life of the species. First, a large number of forms appeared, both in quantity and as *formæ mixtæ*, which had *rounded* outlines and yet were too closely connected with more typical forms to be separated from them and classed by themselves. Secondly, I discovered that between the extremes of the type, on the one hand, and var. *sexangulare* on the other, there might be found every degree of slope in the lower sides. This goes far to prove the connection of them all in one species.

St. monticulosum Bréb., and St. forficulatum Lund.

When a small isolated pool or patch of swampy ground is selected, and the Desmids it contains subjected to close and systematic investigation extending over several years, two things may be expected. Firstly, we may be simply overwhelmed with polymorphic forms, all plainly connected together in life and growth (among which will probably be many well-known "species"), and all anastomosing together, through transition-forms, into a perfect maze. Secondly, a series of forms may be obtained, showing every stage in the development of any given Desmid; and, by patient search, the difference between any two terms of the series may be made as small as desired.

There might be some justification for the theory that a certain similarity in outline is merely the record of evolutionary relationship, provided we were able to retain a reasonable gap between the forms. But when two such evolutionary relations become connected by a series of forms exhibiting no greater difference among themselves than may be found in the figures of a kinematograph film, we are justified in considering that it is the record of one continuous action. Such a series is figured in Pl.xii., f.15-20.

The following are the specifications of the various forms :—

St. orbiculare var. muticum(Bréb.). (Pl.xii., f.15).

Long.30; lat.24; isth.8μ.

Guildford(60).

The semicells become a little more adpressed in the next form, which develops out of this—hence the cells are a little shorter.

Var. GRANULOSUM, n.var. (Pl.xii., f.16).

Forma semicellulis subreniformibus, sinu angusto introrsum rotundato constricta; angulis lateralibus interdum aculeo minuto præditis; apicibus interdum levissime deplanatis; lateribus denticulationibus minutissimis 3-5 instructis. A vertice semicellulæ triangulares; lateribus concavis; angulis inflatis acuminatis aculeo minuto munitis; medio granulis 6 concentrice ordinatis et mediis angulis binis. Membrana minute punctato-scrobiculata. Long. 27-28; lat.24-30; ap.8-10; isth.8-10μ.

Guildford(60).

This form is found sometimes with four denticulations and a spine (or five without) on each side, developing through var. *aculeatum* into the *forficulatum*-form; and sometimes with three denticulations and a spine (or four without) growing directly into var. *bifarium* forma.

Var. ACULEATUM, n.var. (Pl.xii., f.17).

Forma sinu angusto non lineari constricta. Semicellulæ subtriangulares, plus minusve adpressæ; apicibus minime deplanatis; angulis lateralibus in processum bifidum brevissimum productis; lateribus levissime convexis, aculeis brevibus geminatis binis superne instructis et interdum denticulationibus supra processum. A vertice semicellulæ triangulares, interdum angulis inflatis lateribus concavis, interdum angulis planis lateribus pæne aut perfecte rectis; apicibus angulorum constrictis, in processum cylindraceum brevissimum productis. Membrana punctato-scrobiculata. Long. c.ac. 34, s.ac. 30-32; lat. c.proc. 32, s.proc. 28-30; long. spin.circ. 2; ap. 10; isth. 8-10μ.

Guildford(60).

The end-view is at first with inflated angles and hollow sides, as in *St. orbiculare*; but develops into one with flat sides. At this stage, the end-view much resembles that of *St. submonticu-*

losum Roy & Bisset (Jap. Desm., f.7); which is another variant of this species.

Var. BIFARIUM(Nord.) forma. (Pl.xii., f.18).

Forma angulis lateralibus in processum brevem productis; processibus(spinisve) sublateralibus inter angulos et apicem superne positis. Membrana punctato-scrobiculata. Long. c.proc. 25-38, s.proc. 25-30; lat. c.proc.30-36, s.proc.24-26; ap.12-14; isth.10-12μ.
Guildford(60).

Specimens of long.25-28μ, are those in which the apical processes are very short, hardly projecting above the apex. The processes, which in Nordstedt's form are on a level with the lateral angles, are here situated higher up, projecting above the sides in front view; but as the semicell develops, they grow out more and more horizontally, and descend gradually to the level of the lateral processes.

St. Tohopekaligense Wolle,(*cf.* W. & G. S. West, Frw. Alg. Ceyl., p.181, Pl.21, f.27) is a more fully developed form of var. *bifarium*. The shape of the body is that of *St. orbiculare* var. *muticum*, and the size exact(36 × 27, isth.9·5). There is, of course, no specific characteristic in the length of the processes—it stands to reason that they grow longer; nor is the number of spines of any value; it is just as easy for a third and fourth to develop as it was for the first two.

Var. FORFICULATUM(Lund.) forma. (Pl.xii., f.20).

Forma minor, verrucis basalibus et processibus utrinque ad angulos deficientibus. Membrana punctato-scrobiculata. Long. c.proc. 34, s.proc. 30-32 ; lat. c.proc. 36, s.proc. 28-30 ; ap. 14 ; isth. 10-16μ.
Guildford(60, 114).

Var. *forficulatum* is a collateral variation with var. *bifarium* in this line of development. In the latter the apical processes develop at the expense of the others, while in the former it is the lateral processes that do so, the others being reduced (for the time) to mere bifid verrucæ. Lundell's end-view does not seem to be quite accurate. There are three pairs of processes down each side; there should be three, therefore, (besides the sublateral ones) in end-view. The two denticulations at the apex of his figure are the tips of the two apical verrucæ at the head of the foreshortened angle.

A mixed form of the above and var. *bifarium* forma was noted.

Var. AGGERATUM(Playf.), *ante*, 1907, Pl.iv., f.21.

Long. 28; lat. s.sp. 30μ.

Botany.

Both front and end-views are quite correct. Var. *aggeratum* is a young form of var. *forficulatum*, and develops into it through var. *aculeatum*.

Forma. (Pl.xii., f.19*b*).

Forma lateribus apicibusque magis rotundatis, glabris; apicibus quam levissime deplanatis; angulis lateralibus interdum aculeo interdum nullo præditis.

Common round Sydney. This form, like var. *granulosum*, is common to both the *bifarium* and *forficulatum* lines of development. Dimensions noted as yet only in :—

Forma mixta.—var. *bifarium* f. et var. *aggeratum* f., Pl.xii., f.19. Long. c.proc. 35, s.proc. 32; lat. var. *bifar.* c.proc. 38, s.proc. 26; lat.var. *agger.* c.sp. 34, s.sp. 28μ.

Guildford(60).

ST. SEXANGULARE(Bulnh.) Rabenh.

Descriptions of variations illustrating the development of processes.

ST. SEXANGULARE var. STELLINUM(Turn.).

Synonyms, *St. stellinum* Turn., Alg. E. Ind., Pl.15, f.6; *St. sexangulare* f. 5-radiata immatura Playf., *ante* 1907, p.185, Pl.v., f.11. Lat.c.proc.75-120μ.

Collector.

The processes become shorter and stouter as the denticulations form.

Forma mixta.—var. *stellinum* et var. *gemmescens* (infra). Long. c.proc. 34, s.proc.32; lat. *stell.* 98, lat. *gemmesc.* 72μ.

Collector.

Var. PLATYCERUM(Josh.). (Pl.xii., f.9).

Long. 30; lat. corp. 16, c.proc. 76; isth. 10μ.

Sydney Water-supply.

A six-rayed form; only an optical section is given of all the forms. Compare Joshua, Burm. Desm., Pl.24, f.2. Whatever the author intended fig.1 to be, it can be accepted only as the end-view of a four-rayed form. *Cf.* Borge, Austral. süssw., T.2, f.23.

Var. DENTATUM, n.var. (Pl.xii., f.10).

Forma dentibus triangulis singulis vel aculeis validis singulis in vicem processuum superiorum instructa. Long. centr. 30-40; lat. corp. 17-18, c.proc. 64-76; isth. 10; long.spin. ad 12μ.

Sydney Water-supply. Cum priori rarius.

Fig.10*a* shows the spine from another specimen, indicating a second mode of development. Granules form on either side of the spine, and as these grow outwards into spines the upper part of the original falls in and is drawn out flat.

Var. GEMMESCENS, n.var. (Pl.xii., f.11).

Forma processibus superioribus brevissimis, glabris, bifidis; apicibus cellularum interdum productis truncatis. Long.centr. 36; lat.c.proc. 80μ.

Collector.

Var. SUBGLABRUM W. & G. S. West, forma. (Pl.xii., f.12).

Forma processibus superioribus perfecte glabris, vel denticulationibus singulis utrinque munitis. Long.centr. 60; lat.c.proc. 100μ.

Collector.

Var. ASPERUM, n.var. (Pl.xii., f.13).

Forma denticulationibus processuum pæne in aculeos protractis; processibus leviter inflatis. Long.centr. 60; lat.c.proc. 105μ.

Centennial Park. Rarissime.

Pen. spirostriolatum Barker. (Pl.xiii., f.24).

Long. 210; lat. 18; ap. 10μ.

Botany(109).

A cell with costæ more spiral than any I have seen before. The specimen shows very well the development of the membrane. The new growth perfectly hyaline and unstriate, the older portion rufescent and costate.

Cl. rostratum Ehr. (Pl.xiii., f.25).

Forma cum endochroma 6-radiata; vesiculis terminalibus distinctis granulos circ. 7 continentibus. Membrana corporis rufescente, striis nullis. Long.293; long.corp.152; lat.18; ap.3,4μ.

Potts Hill(113).

The beak of the lower semicell approximates to that of *Cl. Kützingii.* This species is a most serious example of the way in which obvious and striking characteristics have been ignored hitherto in the diagnosis of the species, and minute differences, which can often with difficulty be recognised, have been elevated into fundamental specific characters. *Cl. Kützingii*, *Cl. setaceum*, *Cl. pronum* Bréb., and *elegans* Bréb., are all merely growth-variations of *Cl. rostratum* as the nomenclatural type. In this connection it should be noted that W. & G. S. West, in their Monograph, have failed to recognise *Cl. pronum* Bréb. Brébisson in his "Liste," pp.156-157, uses the same words to describe the beak of *Cl. pronum* as of *Cl. setaceum*, viz.:—"prolongement filiforme diaphane," the apex "obtus et même un peu renflé." *Cl. pronum*, which is not uncommon round Sydney along with *Cl. Kützingii*, has a body about one-half the length of the cell, much longer proportionately than in *Cl. setaceum*, and about 8μ broad. Sometimes the body is fusiform and evenly attenuated, but sometimes flat on one side (more or less) and inflated on the other. The latter is Brébisson's form, and gives rise to his remark:—"Ce *Closterium* ressemble au *Cl. gracile.*" The membrane is generally slightly rufescent and faintly striate, the striæ always with difficulty detected. *Cl. elegans* Bréb., in my judgment, is a young form of *Cl. pronum* in which the setaceous beak is not quite formed, the tip acute. Cleve's figure, Sveriges sötvattens-alg., f.8., shows both these forms together, the lower semicell *pronum*, the upper *elegans.* The range of dimensions noted in Australian specimens was:—Long. 159-400; lat. 7-11; ap.circ.2μ; with broader specimens of lat. 13-18 intermingled. The latter verged on *Cl. setaceum*, but the body proportionately longer, and still the tendency in the inflation to be towards the inner side. Brébisson's figures work out at about:—Long.454-483; lat.9-13μ. Raciborski, Desm. Ciast, p.10, Pl.i., f.40, gives—Long.314; lat.8; ap. 2μ—membrana luteola, subtiliter striata. Compare the remarks by Bernard, Protococc. et Desm., p.64, and his figure Pl.i., f.54.

TRIP. GRACILE var. SUPERBUM(Maskell) Nord., forma.
(Pl.xiii., f.26).

Long.semi.c.sp. 290, centr. 278; lat.bas.c.sp. 60, s.sp. 38μ. Botany(2*a*).

This specimen I noticed lately in the same sample that yielded *Trip. serratum* Playf. (*ante* 1907, Pl.ii., f.2). By comparing it with the latter, the development of the teeth may be observed. From the back of each tooth, a second grows out, the two together forming a bifid verruca (cf. var. *ornatum* Borge, Austral· süssw., T.4, f.56). The latter may become still more elaborate by growth of additional verrucæ; note the three basal verticils in my figure. In a note, *l.c.*, p.163, on *Trip. serratum*, I remarked that such a form might develop either into var. *superbum*(Mask.) or into var. *bidentatum* Nord. As a matter of fact it does both. Here we have an example of the former; and lately I noticed a cell of this kind with the teeth of *Cl. serratum* but drawn out at the tips into aculei in length equal to one-half the diameter of the cell, *i.e.*, nearly twice as long as those in Nordstedt's form. All forms of *Triploceras* are growth-variations of one species, viz., *Trip. gracile* Bailey, 1851, *e.g.* var. *verticillatum* Bail., 1848, var. *aculeatum* Nord., var. *bidentatum* Nord., var. *superbum* Mask., var. *occidentale* Turn., var. *bilobatum* Turn., var. *serratum* Playf., and var. *denticulatum*(Playf.) G. S. West. Why not apply this same rule to the other genera ?

DOC. TRABECULA var. DELPONTEI mihi, formæ. (Pl.xi., f.7).

Long. semicell. per ordinem deorsum 210, 133, 133, 162, 180, 162, 140, 310μ.

Slide 110A.

The lengths of the semicells A,A, viz., 210μ and 310μ respectively, show that the original cell was not complete when the first division took place.

EXPLANATION OF PLATES XI.-XIV.

Plate xi.

Fig.1.—*Doc. trabecula* Ehr.(b)+var. *truncatum* (Bréb.)(a) (×232).
Fig.2.— ,, var. *truncatum*(Bréb.) (×232).
Fig.3—The same dividing (×232).
Fig.4.—*Doc. trabecula*—form with square base—outgrowth of fig.5 (×347).
Fig.5.— ,, var. *Farquharsonii*(Roy) (×347).
Fig.6.— ,, var. *ovatum*, n.var. (×347).
Fig.7.— ,, var. *Delpontei* mihi (×116). An example of double division, a phenomenon which is very common but not very often seen, as the chain of cells necessarily breaks up very easily. A,A, the original semicells; B,B, the semicells formed at the first division; C,C, and D,D, semicells formed at the second division.
Fig.8.—*Doc. trabecula* var. *diadematum*, n.var. (×232).
Fig.9.—*Doc. trabecula* more advanced in growth (×347).
Fig.10.— ,, var. *Ehrenbergii*(Bréb.) (×347).
Fig.11.— ,, var. *constrictum*, n.var. (×347).
Fig.12.— ,, var. *Delpontei* mihi (×347).
Fig.13.— ,, var. *crenulatum*(Roy & Bissett) (×347).

Figs.10-13 are four forms found side by side in a mount made from a single mucilaginous growth of desmids. They serve to show the development of var. *Ehrenbergii* into var. *crenulatum*.

Fig.14.—*Doc. trabecula* var. *Delpontei* f. *constricta*, n.f. (×347).
Figs.15-16.—*Doc. trabecula* var. *maximum* Reinsch, Australian forms (×232).
Figs.17-21.—Various forms of apex in *Doc. trabecula* var. *Delpontei* mihi (×463).

Plate xii.

Fig.1.—*Doc. trabecula* var. *Ehrenbergii* (Bréb.) (a) + a *baculum*-shaped semicell (b) (lat.bas.21) showing that the chloroplast alters from an incomplete tube in var. *baculum* to parietal fillets in var. *Ehrenbergii* as the cell develops. The lower portion of the endochrome is still undivided in (a), and the apical part in (b) shows the original axillary lamina. *Pleurotænium* is only the adult form of *Docidium*. (×347).

Fig.2.—*Doc. trabecula* var. *baculum* (Bréb.) showing the tubular parietal chloroplast (×463).

Fig.3.—*Doc. trabecula* var. *baculum* (b) + a younger form in which the basal granules are replaced by fainter plicæ not visible beyond the margin. There is thus no essential difference between the granules and the plicæ (×463).

Fig.4.—*Doc. trabecula* var. *baculoides* (Roy & Bissett), forma (×347). A curious form, uniting the shape af var. *baculoides*, the basal plicæ of var. *baculum* and the size(lat.bas.18) and apical granules of var. *Ehrenbergii*.

Fig.5.—*Doc. trabecula* var. *Ehrenbergii* (Bréb.), forma (×347). Basal portion only, to show the faint plicæ discernible on either side of the isthmus.

Fig.6.—*Doc. trabecula* var. *pygmæum*, n.var. (×463).

Fig.7.—*Doc. trabecula*(b) + var. *truncatum*, a living specimen, showing the "cellular" arrangement of the protoplasm (×347).

Fig.8.—Apex of forms of *D. trabecula*, viz., var. *Ehrenbergii*, var. *baculum*, and var. *pygmæum*, all found together in one gathering(No.109). The cell-wall of all these was strongly punctato-scrobiculate, as shown; at the ends the pores could plainly be seen running through the incrassate membrane (×463).

Fig.9.—*St. sexangulare* Bulnh., var. *platycerum*(Josh.) (×463).

Fig.10.— ,, var. *dentatum*, n.var. (×463).

Fig.11.— ,, var. *gemmescens*, n.var. (×463).

Fig.12.— ,, var. *subglabrum* W. & G. S. West, forma (×463).

Fig.13.— ,, var. *asperum*, n.var. (×463).

Fig.14.— ,, type(×463).

Figs.9-14 show the development of the upper processes in *St. sexangulare*.

Fig.15.—*St. orbiculare* var. *muticum*(Bréb.) (×695).

Fig.16.— ,, var. *granulosum*, n.var. (a) end (×695).

Fig.17.— ,, var. *aculeatum*, n.var. (a) end (×695).

Fig.18.— ,, var. *bifarium*(Nord.) f. (a) end (×695).

Fig.19.—*St, orb.* var. *bifarium* f., (a) + var. *aggeratum* Playf., forma (b). (×463).

Fig.20.—*St. orb.* var. *forficulatum*(Lund.), forma (×695).

Figs. 15-20 show the growth of the processes in *St. monticulosum* Bréb., and *St. forficulatum* Lund., and the development of these desmids out of *St. orbiculare* var. *muticum* (Bréb.) All the forms were found in the same gathering(60) in quantity, except fig. 20.

Fig. 21.—*Doc. trabecula* var. *crenulatum*, showing reticulate incrassation (×463).

Plate xiii.

Fig. 1.—*Cos. rectangulare* var. *quadrigeminatum* Playf., (a) side (×463).
Fig. 2.— ,, var. *notatum*, n. var. (a) side (×463).
Fig. 3.— ,, var. *hexagonum*(Elfv.) W. & G. S. West (a) end (×463).
Fig. 4.—*Cos. rect.* var. *altius* (a) n. var. + var. *dentatum* (b) n. var. (×463).
Fig. 5.— ,, var. *nodulatum* Playf., f. *minor*, n.f. (×695).
Fig. 6.— ,, var. *saxonicum*(Rac.) (×463).
Fig. 7.— ,, var. *cyclopeum*(Playf.) (×695).
Fig. 8.— ,, var. *subhexagonum*, n. var. (a) + var. *cyclopeum*(b) (×695).
Fig. 9.— ,, var. *subreniforme*, n. var. (a) end (×695).
Fig. 10.— ,, var. *reniforme* (a) n. var. + var. *cyclopeum* (b) (×695).
Fig. 11.—*Cos. rectangulare* var. *subhexagonum* forma (×695).
Fig. 12.— ,, var. *repandum*(Nord.), f. (×463).
Fig. 13.— ,, var. *Finmarkiæ*, n. var. (×463).
Figs. 14-15.— ,, var. *australe*, n. var. (×463).
Fig. 16.— ,, var. *ocellatum*, n. var. (×463).
Fig. 17.— ,, var. *rotundatum*, n. var. (×695).
Fig. 18.— ,, var. *patereforme*, n. var. (×695).
Fig. 19.— ,, ,, forma (×695).
Fig. 20.— ,, var. *papillatum*, n. var. (×695).
Fig. 21.— ,, var. *sulcatum*(Nord.) (×695).
Fig. 22.— ,, var. *sexangulare*(Lund.) f. *senilis* (×463).
Fig. 23.—*Doc. trabecula* var. *Brefeldii*(Istv.) (a) + var. *truncatum*(b) (×463).
Fig. 24.—*Pen. spirostriolatum* Barker, forma (×463).
Fig. 25.—*Cl. rostratum* Ehr., (a) + var. *Kützingii*(Bréb.) Klebs (b) (×463).
Fig. 26.—*Trip. gracile* var. *superbum*(Maskell) Nord., forma (×232).

Plate xiv.

Figs. 1-10.—Degeneration in type produced by continuous cell-division due to rise in temperature. The forms are not described or named, as they came about under more or less artificial conditions. (Figs. 7-8 ×347. The rest ×463).

Fig. 1.—*Micr. truncata* var. *decemdentata*(Näg.), the original cells.
Figs. 2-4.—Results of first, second, and third divisions respectively.
Fig. 5.—Result of fourth division. Figs. 5, 4*b* and 6*b* resemble *Micr. incisa* Bréb., cf. Turn., Alg. E. Ind., T. vi., f. 7, 8.

Fig.6.—Result of fifth division; 6*a* is practically *Micr. oscitans* Ralfs, f. *minor*.

Figs.7-8.—Lateral lobules of *Micr. truncata* var.*decemdentata* developing into the type by growth of additional spines and cleavage of lobules.

Figs.9-10.—Examples of continuous division, halves of 4-celled chains (six immature semicells with a more mature semicell at each end); (9) in *Ar. triangularis*; (10) in *Micr. truncata* var. *decemdentata*.

Fig.11.—Part of a very long chain of degenerate cells of *Docidium trabecula* produced by continuous division. The cell A+B has divided a second time before B has completed its previous division, being not yet cut off by a septum. The chloroplasts were continuous through three semicells. All these four cells were alive, and joined into a chain, as marked.